8.15 Geologic Resources and Hazards

The Henrietta Peaker Project (HPP) consists of a 91.4-megawatt (MW) (net), natural-gas-fired, simple-cycle power plant located approximately 10 miles southwest of Lemoore, California, on a seven-acre portion of a 20-acre parcel owned by GWF Energy LLC. The HPP will interconnect to the existing adjacent Pacific Gas and Electric Company (PG&E) Henrietta Substation through a new 550-foot 70-kilovolt (kV) transmission line supported on two new transmission poles. Other linear facilities include an approximately 16.5-foot water interconnection pipeline (from the site property boundary) and a 2.2-mile Southern California Gas Company natural gas interconnection pipeline. Additionally, approximately five acres will be used for temporary construction laydown and parking.

The primary geologic issues at the HPP site are land subsidence and seismic hazards. Approximately 4 feet of land subsidence may have occurred in the vicinity of the HPP site between 1920 and 1970. The majority of the land subsidence is due to withdrawal of groundwater from aquifers in the area (USGS, 2000). Groundwater in the area continues to be used for municipal, industrial, and agricultural purposes.

8.15.1 Affected Environment

8.15.1.1 Regional Geology and Physiography

The HPP site is in the south-central portion of the Great Valley Physiographic Province of California (Figure 8.15-1). The Great Valley is bordered by the Sierra Nevada range on the east, the Coast Ranges on the west, the Tehachapi Mountains on the south, and the Klamath and Cascade Ranges on the north (Figure 8.15-1). This province is comprised of two elongated northwest to southeast-trending basins: the Sacramento basin to the northwest and the San Joaquin basin to the southeast. This province is approximately 435 miles long and 43 to 56 miles wide and is characterized by a thick, relatively undeformed sequence of alluvium and volcanic deposits.

The present-day basin evolved from a late Jurassic to middle Tertiary (40–150 million years [Ma]) marine fore-arc basin (Dickinson, 1981; Castillo and Zoback, 1994). In the late Tertiary (25–30 Ma), a change in the relative motion between the Pacific and North

American plates resulted in the gradual uplift of the Coast Ranges and the eventual isolation of the basin from the ocean. More recent Miocene and lower Pliocene sediments were derived from the neighboring Coast Ranges and the Sierra Nevada (Perkins, 1987). By the late Pliocene (2–3 Ma), subaerial depositional conditions prevailed and Sierra Nevada-derived sediments were deposited in the basins (Bartow, 1987). A simplified present-day basin structure is presented in Figure 8.15-2.

8.15.1.2 Regional Seismotectonic Setting and Seismicity

The western margin of the Great Valley Physiographic Province is termed the Coast Ranges–Central Valley geomorphic boundary (Wakabayashi and Smith, 1994). This boundary is defined by a system of seismically active folds and thrust faults. Earthquakes associated with this system include the 1983 moment magnitude (M) 6.5 Coalinga and the 1985 M 6.1 Kettleman Hills events (Bloch et al., 1993; Wakabayashi and Smith, 1994). The Coast Ranges–Great Valley boundary separates the relatively undeformed strata of the Great Valley from the deformed rocks of the Coast Ranges of California. To be consistent with references, distances in this section are given in kilometers with miles in parenthesis.

Significant Faults. The southern San Joaquin Valley is surrounded by a number of active and potentially active faults, some of which have generated large, damaging earthquakes during historic time (see Historical Seismicity, below). There are approximately 10 Quaternary faults within a 100-kilometer-radius (approximately 60-mile-radius) of the site (Figure 8.15-3). The most significant of these are listed in Table 8.15-1, along with estimates of the maximum credible earthquake (MCE) for each fault. MCE magnitude estimates are based on the Working Group for Northern California Earthquake Potential (1996), Working Group for California Earthquake Probabilities (1995), and empirical relationships among fault rupture length, fault rupture area, and maximum magnitude (Wells and Coppersmith, 1994). The most significant Quaternary faults within 100 km (roughly 60 miles) of the site are discussed briefly below.

San Andreas Fault. The San Andreas fault is the main, active crustal discontinuity separating the northwest-moving Pacific plate from the southeast-moving North American plate (Figure 8.15-3). This right-lateral strike-slip fault extends northwestward from the Gulf of California in Mexico along the western edge of California through the Coast Ranges, then heads offshore and runs parallel to the coast to north of San Francisco Bay, finally terminating near Cape Mendocino. The fault is divided into several earthquake rupture segments, based on differing structural, geomorphic, and seismic characteristics along the fault. The three fault segments nearest to the site are the Mojave, Carrizo, and Cholame segments (Figure 8.15-3). Simultaneous rupture of all three of these fault segments, with a fault length of approximately 315 km (196 miles), would generate an earthquake of moment magnitude (M) 7.8. The 1857 M 7.8 Fort Tejon earthquake ruptured these fault segments and parts of neighboring segments between the Coachella Valley and San Benito. From empirical relationships between fault length and earthquake magnitude (Wells and Coppersmith, 1994), the Mojave, Carrizo, and Cholame fault segments have calculated maximum earthquakes of M 7.5, 7.6, and 7.2, respectively. The 1857 M 7.8 rupture is considered the MCE along this reach of the San Andreas (Table 8.15-1). The closest segment of this fault is approximately 55 km (34 miles) to the southwest of the site (Figure 8.15-3).

Coast Range-Sierran Block Boundary. The Coast Ranges–Sierran Block (CRSB) boundary zone is a complex zone of thrust reverse faulting that marks the boundary between the Coast Range block and the Sierran basement rocks that are concealed beneath the Great Valley sedimentary rocks of the San Joaquin Valley (Figure 8.15-3). This is a complex array of west-dipping thrusts and east-dipping back-thrusts. The CRSB boundary zone extends for over 500 km (300 miles), from near Red Bluff in the northern Sacramento Valley to Wheeler Ridge in the southern San Joaquin Valley (Wakabayashi and Smith 1994; Wong et al., 1988) (Figure 8.15-3). The CRSB boundary zone was the probable source of the 1892 M 6.5 and 6.2 Winters earthquakes and the 1983 M 6.5 Coalinga earthquake (Wong and Ely, 1983; Wong et al., 1988; Bakun, 1999). Although the faults themselves do not rupture to the surface, the CRSB is marked along much of its length by an alignment of fault-propagation folds that form a series of low hills along the western side of the Sacramento and San Joaquin Valleys. At its closest approach, the Kettleman Hills portion of the CRSB boundary zone is only 20 km (12.4 miles) southwest of the site and is capable of generating an MCE of M 6.8 (Figure 8.15-3, Table 8.15-1).

Kern Front Faults. Immediately north and west of Bakersfield are a series of north- and northwest-striking faults with apparent normal, down-to-the-west displacement (Figure 8.15-3). These faults mark the boundary between the sedimentary rocks of the San

Joaquin Valley and the granitic rocks of the Sierra Nevada. A number of these faults, including the Pond-Poso, Kern Front, New Hope, and Premier faults, are either actively creeping or have experienced creep during historic time as a result of aquifer collapse due to groundwater removal (Holzer, 1980). Several of these faults, including the Mt. Poso, Poso Creek, Jewett, and Kern Gorge faults all offset Quaternary deposits. The exact age of fault movement is unknown. Several of these faults experienced ground breaks (possible triggered slip) during the 1952 M 7.3 Arvin-Tehachapi earthquake on the White Wolf fault (Jennings, 1994). The relatively short length of these faults indicates that each is probably only capable of generating an MCE of M 6.5.

Historical Seismicity. The historical earthquake record for the San Joaquin Valley only extends to the mid-1800s, coinciding with the influx of miners and settlers during the Gold Rush (Toppozada et al., 1981; Wong and Ely, 1983). Until adequate seismographic coverage came into existence in southern California in the 1930s, earthquake detection was generally limited to those events that produced felt or physical effects. Earthquakes as small as Richter local magnitude (M_L) 3.0 were probably not completely observed throughout the San Joaquin Valley until about 1960. Thereafter, seismographic coverage in southern California improved significantly, and currently earthquakes as low as M_L 2.5 can be detected for most portions of the San Joaquin Valley.

The site is located in a seismically active area. The largest historical earthquakes have generally occurred along the valley margins. A historical catalog from 1852 to 2000 was compiled for the study region, and the epicentral locations are shown on Figure 8.15-3. The study region encompasses a 100-km-radius (approximately 60-mile-radius) area from the site and includes all seismic sources that may generate potential strong ground shaking.

The catalog was compiled from the following data sources: the National Earthquake Information Center's Preliminary Determination of Epicenters; Stover, Reagor, and Algermission's U.S. historical catalog; the catalog of the California Division of Mines and Geology, 1735–1974; the catalog of the Decade of North American Geology; and the Northern California Seismic Network and the Southern California Earthquake Center catalogs. The resulting catalog (1852–2000) for the study region consists of nearly 1,700 earthquakes of approximate M_L 3.0 and greater (Figure 8.15-3).

Ten earthquakes of estimated M_L 6.0 or greater have occurred in the site region in historical times. The most significant of these events are annotated on Figure 8.15-3 and discussed in more detail below. The closest earthquake to the site (approximately four miles [7 km]) occurred on February 25, 1987 and measured ML 3.0.

1857 Fort Tejon Earthquake. On January 9, 1857, the largest earthquake within the study region ruptured the San Bernardino, Mojave, Carrizo, and Cholame segments of the San Andreas fault (Figure 8.15-3). An M 7.8 has been estimated for the event based on the rupture length, average slip, and comparison to the 1906 earthquake in northern California (Sieh, 1978). The epicenter of the earthquake is near Fort Tejon (Real et al., 1978), 100 km (approximately 60 miles) southwest of the site. Fort Tejon was destroyed (maximum Modified Mercalli intensity [MM] IX), and the effects were felt over an area of at least 135,000 square miles (Townley and Allen, 1939). The site likely experienced a maximum intensity of MM VII to IX (Stover and Coffman, 1993). Instances of fissuring, sandblows, and hydrologic changes were reported from Sacramento to the Colorado River delta. One report describes liquefaction in the region between Stockton and Sacramento (Stover and Coffman, 1993). Reported surface rupture extended over a distance of 230 km (145 miles), possibly as great as 360 km (225 miles), from San Bernardino to San Benito County. Offset channels and alluvial deposits are evidence of at least 6 meters (20 feet) of right-lateral slip during the 1857 event (Grant and Sieh, 1993).

1983 Coalinga Earthquake. The mainshock (M_L 6.5) of a sequence of events occurred on May 2, 1983 near the town of Coalinga beneath the Coalinga anticline (Figure 8.15-3). More than 6,000 aftershocks were recorded over a four-month period; seven of these were greater than M_L 5.0 (Eaton, 1990). The town of Coalinga was heavily damaged, and a four-block industrial area downtown was destroyed. A large number of houses and public buildings also received significant structural damage (Stover and Coffman, 1993). The maximum intensity in the area of the project site was MM V to VI. Although there was no surface rupture associated with the mainshock, Anticline Ridge, northeast of Coalinga, was uplifted by 20 inches (Stein, 1983).

1985 North Kettleman Hills Earthquake. On August 4, 1985, an earthquake occurred beneath the Kettleman Hills–North Dome anticline, a segment of the CRSB boundary zone (Figure 8.15-3). The mainshock ranged in size from M 6.0 to 6.2 (Ekström et al., 1992). Over 400 aftershocks were recorded within a four-week period. Buildings and water lines in the town of Avenal sustained significant damage, and minor damage was widespread. The earthquake was felt over an area of approximately 37,450 square miles.

Parkfield Earthquakes. The Parkfield segment of the San Andreas fault has generated three moderate to large earthquakes, in 1922, 1934, and 1966 (Figure 8.15-3). The 1922 event (M_L 6.3 to 6.5) generated a maximum intensity of MM IX (Townley and Allen, 1939). Major damage was minimal due to sparse population in the epicentral region; however, minor damage was widespread, as intensities of MM IV to V were felt over an area of 25,300 square miles. Surface rupture was noted in Cholame Valley over a distance of about 1,640 feet (Townley and Allen, 1939). The 1934 earthquake occurred in close proximity to the 1922 event and had a maximum intensity of MM VIII. Damage was limited to toppled chimneys within the town of Parkfield, and nearby bridges shifted from their foundations. A 17-km-long (11-mile-long) zone of surface rupture associated with this event was observed at Middle Mountain along the San Andreas fault (Coffman et al., 1982). The 1966 event also occurred near Parkfield and measured M 6.1. The total felt area was 20,000 square miles, and a maximum intensity of MM VII was assigned to a narrow zone of the San Andreas fault where surface rupture was noted (Coffman et al., 1982). Because of similarities in magnitude, location, and southeast unilateral rupture propagation, Bakun and McEvilly (1984) have suggested that these three events along the Parkfield segment are "characteristic" Parkfield earthquakes.

8.15.1.3 Local Geology

The HPP site lies on a flat area of alluvial fan deposits associated with the Kings River. The elevation at the site is approximately 225 feet above mean sea level. Before agricultural and urban development in the area, the alluvial fan deposits were dissected and cut by shallow, meandering sloughs and creeks. Many of the sloughs have been filled and leveled and are now farmed. The topographic gradient slopes gently to the east-southeast, and local drainage is directed towards the Kings River (see Section 8.14, Water Resources).

Structure. The overall structure beneath the San Joaquin Valley consists of an asymmetric syncline (Figure 8.15-2). The axis of this fold is approximately parallel to the valley axis. The western limb of this fold is considerably steeper than the eastern limb. Within this major fold are many smaller folds and several faults. The steeper western limb of the syncline is cut by a number of reverse or thrust faults belonging to the CRSB boundary zone. The eastern limb of the syncline is cut by several west-dipping normal faults.

Stratigraphy. Sources reviewed on the general geology included maps compiled by the California Division of Mines and Geology (CDMG, 1966) and maps published in Croft and Gordon (1968). Results from a geotechnical investigation performed at the site on July 2, 2001 (Kleinfelder, 2001) were also used. The investigation consisted of drilling one exploratory boring to a depth of 76.5 feet below ground surface (bgs). Figure 8.15-4 presents the general stratigraphic column in the HPP area (Croft and Gordon, 1968), and a geological map of the HPP area is presented in Figure 8.15-5.

Sedimentary rocks in the locality of the site range in age from late Mesozoic to Holocene (140 Ma to 10,000 years). The majority of the area is underlain by Quaternary (0–2 Ma) alluvium, which overlies a series of sandstones and shales that represent the filling of a marine basin. This sequence also represents the transition from a marine to a lacustrine and deltaic environment. The sequence was subsequently capped by coalescing alluvial fan deposits. The lithologies of the stratigraphic column at the site, from oldest to youngest, are briefly described below.

The study region is ultimately underlain by the Mesozoic crystalline basement of the Sierra Nevada block (Figures 8.15-2 and 8.15-4). This folded and faulted Mesozoic basement is overlain by a sequence of upper Jurassic to Quaternary sedimentary rocks, commonly called the Great Valley Sequence. This is essentially a thick succession of marine shales with interbedded greywacke. These clastic deposits were derived from a source to the east, as they lack any granitic detritus that would indicate a Salinian origin (Page, 1966). In addition to these marine deposits, the lower part of the Great Valley Group contains basaltic pillow lavas, breccias, and volcanoclastic deposits in some localities. This sequence is generally found at a depth of approximately 21,000 feet in the San Joaquin Valley (Bloch et al., 1993).

Above the Great Valley Group is the Lower Tertiary sequence, comprised of siliceous to calcareous shales and sandstones representing deep marine, continental shelf, and possibly deltaic depositional environments (Medwedeff, 1989) (Figures 8.15-2 and 8.15-4). The transition from marine to terrestrial deposition occurred during the Pliocene (2–5 Ma). Lower Pliocene rocks are shallow marine, while overlying, younger formations tend to be consistent with a brackish-water paleoenvironment. Fluvial and lacustrine siltstones, sandstones, and conglomerates are typical of sedimentary layers deposited during the Pliocene to Pleistocene. Above these units the recent Quaternary alluvium was deposited (Holocene or post-Holocene age).

Surficial sedimentary units of predominantly Pleistocene and Holocene to Recent age underlie the entire project area (noted as Qal, Quaternary undifferentiated, in Figure 8.15-5). These sediments include deposition that ranges from continental alluvial, fluvial, lacustrine, fan-derived sediments to subaerial floodplain deposits. Lithologies encountered at the proposed site area during the geotechnical investigation conducted in July 2001 (Kleinfelder, 2001) consisted of soft to stiff lean clay, extending to a depth of about 33 feet. These clay soils were underlain by alternating layers of medium-dense silty sand and poorly graded sand, extending to a depth of about 46 feet. These sand soils were underlain by medium-stiff to very stiff lean clay, extending to a depth of about 72 feet. Between 72 and 76.5 feet, the encountered soil consisted of medium-dense, silty sand with high plasticity. Total thickness of these units is approximately 200 feet (Croft and Gordon, 1968).

Soils. The entire project area is covered by Lethent clay loam (see Section 8.9, Agriculture and Soils). This soil consists of brownish to yellowish sandy and clay loam and has a very low permeability. The soil type has a high concentration of salts and is alkaline. Excavations for roads or building site pads can expose material that may be susceptible to wind and/or water erosion. The loose nature of the soil limits its use for embankments, dikes, and levees.

8.15.1.4 Hydrogeology

The HPP site is located in the southern portion of the San Joaquin Valley groundwater basin, which is the largest groundwater basin in California. The basin covers approximately 13,500 square miles and has a storage capacity of 570 million acre-feet.

One of the principal subsurface geological features of the San Joaquin Valley is the Corcoran Clay formation within the Tulare Formation. Formed as a lakebed about 600,000 years ago, this clay layer ranges in thickness from 20 to 200 feet. Varying in depth from 200 to 600 feet bgs in the valley, the Corcoran Clay divides the groundwater system into two major aquifers, a confined aquifer below and a semiconfined above (Westlands Water District, 1996). The entire HPP area is underlain by the Corcoran Clay unit, which is located approximately 500 to 600 feet bgs (Croft and Gordon, 1968; Mayer, 2001). This unit is not continuous west of Huron, 8.5 miles from the HPP (Westlands Water District, 1996).

The groundwater basin underlying the HPP area is comprised of two main water-bearing zones: (1) an upper zone above a nearly impervious Corcoran Clay layer containing the Coastal and Sierran aquifers, and (2) a lower zone below the Corcoran Clay containing the Sub-Corcoran aquifer. The water-bearing zones are recharged by subsurface percolation of groundwater and by imported and local surface water. The lower aquifer underlies the Corcoran Clay and consists of interbedded sands and clays. Depth to water in this unit in the vicinity of the HPP area varied between 200 and 400 feet in December 2000 (Westlands Water District, 2001). In the study area, most of the wells encountered were drilled in this aquifer unit and are used for irrigation. The upper aquifer generally consists of interbedded sands and clays that contain water under unconfined or semiconfined conditions. As of spring 1999, the groundwater elevation in these aquifers were located at approximately 80 feet bgs, though well depths to groundwater vary from 50 to over 200 feet bgs within the general project area (Mills, 2000; Westlands Water District, 2001). The presence of clay layers within the upper aquifer induces perched water in the area. In the site vicinity, perched groundwater was located between approximately 10 to 20 feet bgs in 1997 (San Joaquin Water District, 2001) and was encountered at about 6 feet bgs in July 2001 (Kleinfelder, 2001).

8.15.1.5 Resources of Recreational, Commercial, or Scientific Value

No information was found to indicate that the HPP will adversely affect geologic resources of recreational, commercial, or scientific value.

At the HPP site and along the proposed transmission route, the geologic units at the surface and in the subsurface are widespread throughout the southwestern part of the San Joaquin Valley; these alluvial deposits are not unique in terms of recreational, commercial, or scientific value. The potential for the presence of rare minerals is very low, given the geologic environment in the area (see also Section 8.16, Paleontological Resources). Furthermore, the HPP site has been disturbed by previous industrial activities. Therefore, it is unlikely that undiscovered near-surface resources will be adversely affected by the construction associated with the HPP.

The HPP is located in a sedimentary basin where oil, gas, and geothermal energy are produced. However, no oil, gas, or geothermal fields are currently in production within 15 miles of the project site (CDOG, 2001). Therefore, the HPP will not adversely affect the commercial value of any energy resources. If further oil or natural gas reserves were discovered at a later date, the reserves could be tapped by directional drilling, even if they were directly beneath the facilities.

Deeper excavation at the plant site and other related facilities could disturb soils that have a high potential for significant paleontological resources to occur (see Section 8.16, Paleontological Resources). However, if a mitigation program is adopted during the construction phase of the project, the direct, indirect, and cumulative adverse environmental impacts on paleontological resources will be reduced to insignificant levels.

8.15.2 Geologic Effects and Hazards

No geologic hazards were identified for the proposed HPP that will preclude construction. However, surface fault rupture, earthquake ground shaking, soil liquefaction, landsliding, subsidence, expansive soils, and erosion must be considered in the final design and construction.

8.15.2.1 Surface Fault Rupture

Surface fault rupture occurs when an active fault intercepts and offsets the earth's surface. The State of California delineates zones around active faults under the Alquist-Priolo Earthquake Fault Zoning Act (Hart, 1994) in order to mitigate for the effects of surface faulting. The nearest Alquist-Priolo special studies zone is the San Andreas fault zone, approximately 60 km (37 miles) from the HPP site (California Department of Conservation, 2000). The nearest fault to the HPP site is probably a buried fault approximately 20 km (12 miles) southeast within the CRSB boundary zone in the Kettleman Hills. Based on these data, the hazard from ground rupture is considered to be insignificant.

8.15.2.2 Earthquake Ground Shaking

No known active or potentially active faults pass through or are close to the HPP site (Jennings, 1994). The closest active faults are associated with the Kettleman Hills segments of the CRSB boundary zone approximately 20 km (12 miles) southeast of the site. An active fault is defined as having had movement along its trace at least once during the Holocene (approximately the last 11,000 years). However, the site is also within about 60 miles of several major active fault systems. The two most important faults considered most likely to cause significant ground-shaking motion at the HPP site, the CRSB boundary zone and the San Andreas fault, are listed in Table 8.15-1 (see Section 8.15.1.2 for a description).

The California Building Code (CBC) (1998) provides the seismic standards specified by the California Energy Commission (CEC) for non-nuclear plants such as the HPP. Under the criteria of the code, the entire project area is within CBC Seismic Zone 3 and therefore will have a Z value of 0.30. The Z value is used to calculate seismic forces for the design of structures located in certain zones.

To estimate the ground shaking that might occur at the project site in a future earthquake, median estimates of the ground motion parameter, peak ground acceleration, were made using four empirical attenuation relationships and the estimates of the maximum earthquakes listed in Table 8.15-1. The maximum value, assuming soil conditions at the project site, is expected to occur from a M 6.5 earthquake on the Kettleman Hills portion of the CRSB for the closest horizontal distance to vertical projection of the rupture assumed of 1 km (0.62 mile). Such an event would result in a median peak ground acceleration of 0.35 g (35 percent of the acceleration under the force of "g," or gravity).

In the most recent update of the U.S. Geological Survey (USGS) national hazard maps, which are the basis for CBC criteria, Frankel et al. (1997) estimated probabilistic ground motions for the U.S. for a 10 percent exceedance probability in 50 years (approximate 500-year return period). From the USGS maps, the 500-year return period peak horizontal ground acceleration at the project area is 0.24 g. The ground motions calculated by the USGS assume soft rock soil conditions; however, the project site is situated alluvial fan deposits that are 100 or more feet thick. As a result, ground motions would be modified by the site response of the soil.

8.15.2.3 Soil Liquefaction

Liquefaction is the phenomenon in which loose, saturated, cohesionless soils temporarily lose shear strength during strong ground shaking. Significant factors known to affect the liquefaction potential of soils are the characteristics of the material, such as grain size distribution, relative density, degree of saturation, the initial stresses acting on the soils, and the characteristics of the earthquake, including the intensity and duration of the ground shaking. Under conditions of liquefaction, granular materials lose all bearing capacity and become fluid.

The geotechnical investigation (Kleinfelder, 2001) concluded that seismically induced settlement could occur in various granular zones between 38 and 46 feet in depth. This settlement is estimated to be less than 1 inch. Consequently, seismically induced differential settlement at the surface will not be significant.

8.15.2.4 Landsliding

The site is on a flat alluvial fan surface. The relatively stable soil and the lack of any significant slopes on or near the site indicate that the hazard from slope instability (landslides and debris flows/lateral spreads) is negligible.

8.15.2.5 Subsidence

The southern San Joaquin Valley has been subsiding. Maps for the San Joaquin Valley indicate that approximately 4 feet of subsidence may have occurred in the vicinity of the HPP site between 1920 and 1970; as much as 8 feet of subsidence is reported in the area about one mile southeast of the HPP site. The primary cause of land subsidence has been the compaction of fine-grained sediments (predominately clay) in the aquifer system following long-term withdrawal of groundwater in excess of recharge (USGS, 2000). Subsidence in the area has coincided with a water level decline on the order of 100 feet or more (USGS, 2000). Groundwater beneath the project area is used for agricultural, domestic, and industrial purposes (see Section 8.14, Water Resources), and the rate of subsidence is generally dependent on the demand for groundwater. If long-term demand for groundwater grows, the rate of land subsidence may increase due to the increase in groundwater withdrawal.

The engineering design of major equipment foundations will incorporate subsidence considerations, including such factors as selection of foundation type, foundation dimensions, foundation location, and extent of soil recompaction. Final foundation designs that minimize subsidence impacts to insignificant levels will be submitted to the Compliance Program Manager and the County Building Official for review prior to commencement of construction.

8.15.2.6 Expansive Soils

Certain soils, especially those containing smectite and mixed-layer clays, have the ability to shrink and swell depending on their moisture content. While the soils are wet, the clay crystal structure absorbs water, leading to expansion or swelling. This expansion causes the ground surface to rise. The site soils consist of lean clay extending to a depth of about 30 feet, with a groundwater table level ranging between 6 and 20 feet bgs. These conditions could result in a moderate to high expansion potential.

The engineering design of major equipment foundations will incorporate additional geotechnical investigation results and soil expansion considerations, including such factors as selection of foundation type, foundation dimensions, foundation location, and extent of soil recompaction. Final foundation designs that minimize soil expansion impacts to insignificant levels will be submitted to the Compliance Program Manager and the County Building Official for review prior to commencement of construction.

8.15.2.7 Erosion

The site is on a flat alluvial fan surface. The relatively stable soil and the lack of significant slopes on or near the site indicate that the hazard from erosion is negligible.

8.15.3 Cumulative and Indirect Impacts

No cumulative and indirect (or growth-inducing) impacts have been identified with regard to geologic resources or hazards.

8.15.4 Mitigation Measures

Mitigation measures are necessary for the HPP because of potential geologic hazards. The following mitigation measures will reduce potential impacts to a less-than-significant level.

- The HPP and transmission route will be designed to conform with the CBC requirements for Seismic Zone 3 and an estimated seismic coefficient of 0.3.
- Geotechnical investigations will be performed to better define the soil characteristics.
- The project will be designed and constructed to account for geologic hazards (see Appendix K, Facility Design)

No mitigation measures are required for geologic resources because the HPP will not have a significant impact on geologic resources of recreational, commercial, or scientific value.

8.15.5 Laws, Ordinances, Regulations, and Standards

The laws, ordinances, regulations, and standards (LORS) that apply to geologic resources and hazards for the HPP are presented in Table 8.15-2. Only LORS for state and local authorities are listed in the table, as no federal LORS apply.

California Public Resources Code, Section 25523(a); California Code of Regulations (CCR), Sections 1752, 1752.5, 2300–2309, and Chapter 2, Subchapter 5, Article 1, Appendix B, Part (i): These regulations stipulate the environmental review and siting procedures to be followed for the development of power generation projects larger than 50 megawatts. The CEC is the administering agency for this authority. The project applicant will be in compliance with this authority by submitting all information on environmental impacts to soil and agriculture to the CEC and implementing the mitigation measures identified in the final certification.

CBC, 1998. Appendix Chapter 16, Division 4: This section of the CBC describes design requirements that ensure structures will withstand the effects of earthquake ground motions that could cause them to collapse.

Safety Element of the Kings County General Plan (1993): The safety element of the county's general plan sets forth policies that are intended to reduce loss of life, serious injury, property damage, and economic and social dislocation resulting from a seismic event. The county's general plan requires adherence to construction standards and outlines zoning and building permit review procedures.

8.15.6 Proposed Conditions of Certifications

Proposed conditions of certification are contained in Appendix K. These conditions are proposed in order to ensure compliance with applicable LORS and/or to reduce potentially significant impacts to less-than-significant levels.

8.15.7 Involved Agencies and Agency Contacts

Agency	Contact/Title	Telephone
Kings County – Building Department 1400 West Lacey Blvd., Building #6 Hanford, CA 93230	Carl Goss Deputy Building Officer	(559) 582 3211 ext. 2687

8.15.8 Permits Required and Permit Schedule

No permit requirements that specifically address geologic resources and hazards were identified.

8.15.9 References

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TABLES

Table 8.15-1
MCE Median (50th Percentile) Peak Horizontal Ground Accelerations on Soil

			Distances in km			Peak Horizontal Ground Acceleration					
Seismic Source	MCE (M_w)	Fault Style	Horizontal	Rupture[1]	Seismogenic[2]	Abrahamson & Silva (1997)	Campbell (1997)	Sadigh et al. (1997)	Boore et al. (1997)	Spudich et al. (1999)	Weighted Average PGA
San Andreas Fault (Parkfield Segment)	8.0	S	65	65	65	0.11	0.15	0.12	0.14	--	0.13
CRSB (Kettleman Hills)	6.5	R	1	12	12	0.29	0.35	0.31	0.49	--	0.35
Kern Front Faults	6.8	N	67	67	69.3	0.05	0.05	0.05	--	0.05	0.05

N = Normal Slip, S = Strike Slip, R = Reverse Slip
PGA = peak ground acceleration
CRSB = Coast Ranges–Sierran Block
MCE = maximum credible earthquake
[1] Assume faults extend to depth of 12 km
[2] Assume depth to seismogenic portion of fault is 2 km

Table 8.15-2
Laws, Ordinances, Regulations, and Standards
for
Geologic Resources and Hazards

Jurisdiction	Authority	Administering Agency	AFC Conformance Section
Federal	None applicable	—	—
State	California Public Resources Code § 25523(a); CCR §§ 1752, 1752.5, 2300–2309, and Chapter 2, Subchapter 5, Article 1, Appendix B, Part (I)	California Energy Commission	Section 8.15.1
Local	California Building Code (CBC), 1998. Appendix Chapter 16, Division 4. Alquist-Priolo Earthquake Fault Zoning Act (1994 rev).	Kings County Community Development – Building Department	Section 8.15.2
	Safety Element of the Kings County General Plan.	Kings County Community Development – Building Department	Section 8.15.2

CCR = California Code of Regulations

FIGURES